HW13 - 1st Law and Calorimetry

1 1 point

A 100 W electric heater (1 W = 1 J/s) operates for 11 min to heat the gas in a cylinder. At the same time, the gas expands from 1 L to 6 L against a constant atmospheric pressure of 3.527 atm. What is the change in internal energy of the gas?

- 48.37 kJ
- 62.47 kJ
- 67.79 kJ
- 64.21 kJ

2 1 point

The definition of internal energy is
$\Delta U = q + w$
Which of these three values are state functions? Select all of the correct answers.

- q
- w
- ΔU

3 1 point

When 2.00 kJ of energy is transferred as heat to nitrogen in a cylinder fitted with a piston with an external pressure of 2.00 atm, the nitrogen gas expands from 2.00 to 5.00 L. What is the change in internal energy of this system?

- -0.608 kJ
- +2.61 kJ
- -2.61 kJ
- 0
- +1.39 kJ

4 1 point

A system had 150 kJ of work done on it and its internal energy increased by 60 kJ. How much energy did the system gain or lose as heat?

- The system lost 210 kJ of energy as heat.
- The system gained 60 kJ of energy as heat.
- The system gained 90 kJ of energy as heat.
- The system lost 90 kJ of energy as heat.
- The system gained 210 kJ of energy as heat.

5 1 point

If a process is carried out at constant pressure and the volume of the system decreases, then ΔV is

_____ and the work is _____.

positive | negative | positive | negative | zero

6 1 point

Which of the following will best help determine the direction of heat flow in a system?

- enthalpy
- temperature
- internal energy
- pressure
- work

7 1 point

Which of the following statements concerning the first law of thermodynamics is/are true? Select all of the correct answers.

- The internal energy of the universe is always increasing.
- The universe is an isolated system.
- Internal energy lost by a system is always gained by the surroundings.

8 1 point

What is the value of work when a piston of volume 0.2 L expands against an external pressure of 200 kPa to a volume of 3.4 L?

- 3.40 kJ
- -3.40 kJ
- -640 J
- 640 J

9 1 point

When 4.00 kJ of energy is transferred as heat to nitrogen in a cylinder fitted with a piston at an external pressure of 3.00 atm, the nitrogen gas expands from 1.00 L to 4.00 L against this constant pressure. What is ΔU for the process? Note: 1 L· atm = 0.1013 kJ.

- -0.912 kJ
- +3.09 kJ
- -4.91 kJ
- +4.91 kJ

10 1 point

A piece of metal with a mass of 22 g at 92 °C is placed in a calorimeter containing 53.7 g of water at 21 °C. The final temperature of the mixture is 55.3 °C. What is the specific heat capacity of the metal? Assume that there is no energy lost to the surroundings.

- $9.5\ J\ g^{-1}°C^{-1}$
- $1.3 \times 10^4 J\ g^{-1}°C^{-1}$
- $-1.3 \times 10^4 J\ g^{-1}°C^{-1}$
- $-9.5\ J\ g^{-1}°C^{-1}$

11 1 point

Consider the following specific heat capacities:
H_2O (s) = 2.09 J/g·°C
H_2O (l) = 4.18 J/g·°C
H_2O (g) = 2.03 J/g·°C
The heat of fusion for water is 334 J/g and its heat of vaporization is 2260 J/g. Calculate the amount of heat required to convert 93 g of ice at -36°C completely to liquid water at 35°C.

- 7 kJ
- 52 kJ
- 38 kJ
- 21 kJ

12 1 point

The specific heat for liquid argon and gaseous argon is 25.0 J/mol·°C and 20.8 J/mol·°C, respectively. The enthalpy of vaporization of argon is 6506 J/mol. How much energy is required to convert 1 mole of liquid Ar from 5°C below its boiling point to 1 mole of gaseous Ar at 5°C above its boiling point?

- 125 J
- 229 J
- 6610 J
- 6735 J
- 6631 J

13 1 point

Carbon monoxide reacts with oxygen to form carbon dioxide by the following reaction:
$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$
ΔH for this reaction is -135.28 kcal. How much heat would be released if 12.0 moles of carbon monoxide reacted with sufficient oxygen to produce carbon dioxide? Use only the information provided in this question.

- 135 kcal
- 812 kcal
- 1620 kcal
- 412 kcal

14 1 point

What mass of liquid ethanol (C_2H_5OH) must be burned to supply 500 kJ of heat? The standard enthalpy of combustion of ethanol at 298 K is -1368 kJ/mol.

- 10.9 g
- 126 g
- 16.8 g
- 29.7 g

15 1 point

Burning 1 mol of methane in oxygen to form CO_2 (g) and H_2O (g) produces 803 kJ of energy. How much energy is produced when 3 mol of methane is burned?

- 803 kJ
- 268 kJ
- 1606 kJ
- 2409 kJ

16 1 point

Consider the following chemical equation:
$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ ΔH = -2220 kJ/mol rxn
How much thermal energy is given off when 11.0 g of propane gas (C_3H_8) is burned at constant pressure?

- 26.0 kJ
- 2220 kJ
- 555 kJ
- 1670 kJ

17 1 point

For a certain reaction at constant pressure, the change in internal energy is -52 kJ. In addition, the system does 46 kJ of expansion work. What is ΔH for this process?

- 98 kJ
- -98 kJ
- -6 kJ
- 6 kJ

18 1 point

If the products of a reaction have higher energy than the reactants, then the reaction...

- is endothermic.
- is not spontaneous.
- is exothermic.
- must be spontaneous.

19 1 point

The specific heats and densities of several materials are given below:

Material	Specific Heat (cal/g·°C)	Density (g/cm^3)
Brick	0.220	2.0
Concrete	0.270	2.7
Steel	0.118	7
Water	1.00	1.00

Calculate the change in temperature produced by the addition of 1 kcal of heat to 100 g of steel.

- 1.43°C
- 37.0°C
- 84.7°C
- 1.18°C

20 1 point

A 1.00 g sample of *n*-hexane (C_6H_{14}) undergoes complete combustion with excess O_2 in a bomb calorimeter. The temperature of the 1502 g of water surrounding the bomb rises from 22.64°C to 29.30°C. The heat capacity of the hardware component of the calorimeter (everything that is not water) is 4042 J/°C. What is ΔU for the combustion of *n*-C_6H_{14}? One mole of *n*-C_6H_{14} is 86.1 g. The specific heat of water is 4.184 J/g·°C.

- -9.96×10^3 kJ/mol
- -5.92×10^3 kJ/mol
- -4.52×10^3 kJ/mol
- -1.15×10^4 kJ/mol

21 1 point

When 0.485 g of compound X is burned completely in a bomb calorimeter containing 3000 g of water, a temperature rise of 0.285°C is observed. What is ΔU of the reaction for the combustion of compound X? The hardware component of the calorimeter has a heat capacity of 3.81 kJ/°C. The specific heat of water is 4.184 J/g·°C, and the MW of X is 56.0 g/mol.

- -4660 kJ/mol
- 4660 kJ/mol
- 538 kJ/mol
- -538 kJ/mol

22 1 point

Nitric acid can be manufactured in a multi-step process, during which nitric oxide is oxidized to create nitrogen dioxide.
$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
Calculate the standard reaction enthalpy for the above reaction using the following thermodynamic data.
$N_2(g) + O_2(g) \rightarrow 2NO(g)$ $\Delta H°_1 = 180.5$ kJ/mol rxn
$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$ $\Delta H°_2 = 66.4$ kJ/mol rxn

- -246.9 kJ/mol rxn
- -252.4 kJ/mol rxn
- -100.3 kJ/mol rxn
- -114.1 kJ/mol rxn

23 1 point

Calculate the standard reaction enthalpy for the following chemical equation.

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$$

Use the following thermochemical equations to solve for the change in enthalpy.

$2H_2(g) + CO(g) \rightarrow CH_3OH(l)$ ΔH° = -128.3 kJ/mol
$2CH_4(g) + O_2(g) \rightarrow 2CH_3OH(l)$ ΔH° = -328.1 kJ/mol
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ ΔH° = -483.6 kJ/mol

- +216 kJ/mol
- +155.5 kJ/mol
- +206.1 kJ/mol
- +42.0 kJ/mol

24 1 point

Calculate the standard enthalpy change for the following chemical equation.

$$2HCl(g) + F_2(g) \rightarrow 2HF(l) + Cl_2(g)$$

Use the following thermochemical equations to solve for the change in enthalpy.

$4HCl(g) + O_2(g) \rightarrow 2H_2O(l) + 2Cl_2(g)$ ΔH° = -202.4 kJ/mol rxn
$\frac{1}{2}H_2(g) + \frac{1}{2}F_2(g) \rightarrow HF(l)$ ΔH° = -600.0 kJ/mol rxn
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ ΔH° = -285.8 kJ/mol rxn

- +1088.2 kJ/mol rxn
- +516.6 kJ/mol rxn
- -1116.6 kJ/mol rxn
- +1015.4 kJ/mol rxn
- +1116.6 kJ/mol rxn
- -516.6 kJ/mol rxn
- -1587.2 kJ/mol rxn
- -1015.4 kJ/mol rxn
- -1088.2 kJ/mol rxn
- +1587.2 kJ/mol rxn

25 1 point

Calculate the standard enthalpy change for the following chemical equation.

$$4FeO(s) + O_2(g) \rightarrow 2Fe_2O_3(s)$$

Use the following thermochemical equations to solve for the change in enthalpy.

$Fe(s) + \frac{1}{2}O_2(g) \rightarrow FeO(s)$ ΔH = -269 kJ/mol
$2Fe(s) + 3/2\ O_2(g) \rightarrow Fe_2O_3(s)$ ΔH = -825 kJ/mol

- 556 kJ/mol
- -2726 kJ/mol
- 574 kJ/mol
- -556 kJ/mol
- -574 kJ/mol

26 1 point

Calculate the enthalpy change for the following chemical equation.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

Use the following thermochemical data to solve for the change in enthalpy.

ΔH_f for $SO_2(g)$ = -16.9 kJ/mol
ΔH_f for $SO_3(g)$ = -21.9 kJ/mol

- -77.6 kJ/mol rxn
- -5.0 kJ/mol rxn
- -10.0 kJ/mol rxn
- +5.0 kJ/mol rxn

27 1 point

Which of the following substances have $\Delta H_f° = 0$? Select all of the correct answers.

- F_2 (g)
- C (s, graphite)
- HCl (g)
- Na (s)
- HCl (aq)
- C (s, diamond)

28 1 point

Calculate the average S–F bond energy in SF_6 using the following ΔH_f values:

SF_6 (g) = -1209 kJ/mol
S (g) = 279 kJ/mol
F (g) = 79 kJ/mol

- 289 kJ/mol bonds
- 582 kJ/mol bonds
- 196 kJ/mol bonds
- 327 kJ/mol bonds
- 416 kJ/mol bonds

29 1 point

Using the bond energy data provided, calculate ΔH for the following reaction:

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

Bond Energies

H–H	436 kJ/mol
Cl–Cl	242 kJ/mol
H–Cl	432 kJ/mol

- 186 kJ/mol
- -246 kJ/mol
- 246 kJ/mol
- -186 kJ/mol

30 1 point

The standard molar enthalpy of formation of NH_3 (g) is -46.11 kJ/mol. What is the standard molar internal energy of formation of NH_3 (g)?

- -48.59 kJ/mol
- 2433 kJ/mol
- -43.63 kJ/mol
- -2525 kJ/mol